CLAIMS

We Claim:

1. A method for lubricating a surface of a microelectromechanical device, comprising:

attaching the microelectromechanical device to a package substrate;

disposing a container containing a lubricant proximate to the device, wherein the containing has an opening for allowing the lubricant to evaporate from inside the container to the surface of the device; and

sealing the package substrate with a package cover.

2. The method of claim 1, wherein the lubricant is a liquid.

3. The method of claim 1, further comprising:

heating the device to a temperature of from 20°C to 200°C degrees.

4. The method of claim 3, wherein the step of heating the device further comprising:

heating the device to the temperature for a time period of from 5 minutes to 24 hours.

5. The method of claim 1, wherein the step of sealing the package substrate further comprising:

hermetically sealing the package substrate and the package cover using a sealing material.

6. The method of claim 1, wherein the container is a capillary tubing.

7. The method of claim 1, wherein the container is a capillary cylinder.

8. The method of claim 6, wherein the capillary tubing has an interior diameter of from 2 to 500 micrometers.

9. The method of claim 6, wherein the capillary tubing has an interior diameter of from 100 to 200 micrometers

10. The method of claim 6, further comprising:

before disposing the container proximate to the device,

dipping an opening end of the capillary tubing into a lubricant solution comprising the lubricant such that an amount of the lubricant is wicked into the capillary tubing.

11. The method of claim 10, wherein the amount of the lubricant is determined by an interior volume of the capillary tubing.

12. The method of claim 1, further comprising:

before disposing the container,

filling the container with the lubricant by a surface force between the container and the lubricant.

13. The method of claim 1, wherein the container has an interior volume that generally equals a particular amount of lubricant necessary for lubricating the surface.

14. The method of claim 13, wherein the particular amount of the lubricant is from 10 pl to 10 μl.

15. The method of claim 13, wherein the particular amount of the lubricant is from 30 pl to 2 μl.

16. The method of claim 1, wherein the lubricant comprises a perfluoropolyether.

17. The method of claim 16, wherein the perfluoropolyether has a molecular weight of from 500 to 5000.

18. The method of claim 1, wherein the lubricant comprises a perfluorinated hydrocarbon.

19. The method of claim 18, wherein the perfluorinated hydrocarbon comprises 20 carbons or less.

20. The method of claim 19, wherein the perfluorinated hydrocarbon is selected from alkanes, alcohols, ethers and glycols.

21. The method of claim 19, wherein the lubricant comprises an amine.

22. The method of claim 16, wherein the lubricant has a melting temperature of around 50°C or lower.

23. The method of claim 16, wherein the lubricant has a boiling temperature of around 100°C or higher.

24. The method of claim 16, wherein the lubricant has a surface tension of 20 dynes /cm or lower.

25. The method of claim 16, wherein the lubricant has a viscosity in liquid phase of from 1cP to 100 cP.

26. The method of claim 1, wherein the lubricant is mixed with a diluent that comprises: a perfluorinated hydrocarbon.

27. The method of claim 26, wherein the lubricant diluent is liquid at room temperature.

28. The method of claim 26, wherein the lubricant diluent does not decompose at a temperature of 200°C.

29. The method of claim 1, wherein the step of disposing the container on the package substrate further comprising:

fixing the container in the package such that the container can not move.

30. The method of claim 1, wherein the container is placed in a cavity separated from a cavity in which the microelectromechanical device is placed, but connected to the cavity

having the microelectromechanical device via a tunnel or a hole such that the lubricant evaporated from the container can pass through.

31. The method of claim 30, wherein the cavity having the container is in the package cover.

32. The method of claim 30, wherein the cavity having the container is in the package substrate.

33. The method of claim 6, wherein the capillary further comprises:

a coating film on the interior surface of the capillary tubing for improving the wettability to the lubricant.

34. The method of claim 6, wherein the capillary further comprises:

a coating film on the exterior surface of the capillary tubing for reducing the wettability to the lubricant.

35. The method of claim 6, wherein the capillary further comprises:

a coating film on the interior surface of the capillary tubing for improving the wettability to the lubricant; and

a coating film on the exterior surface of the capillary tubing for reducing the wettability to the lubricant.

36. A method for lubricating a surface of a microelectromechanical device, comprising:

preparing a capillary tubing containing a lubricant that evaporates from an opening-end of the capillary tubing;

placing the prepared capillary tubing into a package having the microelectro-mechanical device;

sealing the package; and

heating the package such that the lubricant evaporated from the opening-end of the capillary tubing contact the surface to be lubricated.

37. The method of claim 36, wherein the step of preparing the capillary tubing further comprising:

dipping the opening-end of the capillary tubing into a lubricant fluid containing the volatile lubricant for allowing a particular amount of the lubricant to be wicked into the capillary tubing by capillary force.

38. The method of claim 37, wherein the lubricant fluid further comprises: a volatile diluent.

39. The method of claim 37, wherein the capillary tubing has an interior diameter of from 2 to 500 micrometers.

40. The method of claim 39, wherein the capillary tubing has an interior diameter of from 100 to 200 micrometers.

41. The method of claim 38, wherein the capillary tubing has a length of from 0.1 centimeter to 5 centimeters.

42. The method of claim 41, wherein the capillary tubing has a length of around 1 centimeter.

43. The method of claim 37, wherein the particular amount of the lubricant wicked into the capillary is from 10pl to 10μl.

44. The method of claim 37, wherein the particular amount of the lubricant wicked into the capillary is from 30pl to 2μl.

45. The method of claim 36, wherein the lubricant comprises a perfluoropolyether.

46. The method of claim 45, wherein the perfluoropolyether has a molecular weight of from 500 to 5000.

47. The method of claim 36, wherein the lubricant comprises a perfluorinated hydrocarbon.

48. The method of claim 47, wherein the perfluorinated hydrocarbon comprises 20 carbons or less.

49. The method of claim 48, wherein the perfluorinated hydrocarbon is selected from alkanes, amines, alcohols, ethers and glycols.

50. The method of claim 36, wherein the lubricant comprises an amine.

51. The method of claim 45, wherein the lubricant has a melting temperature of around 50°C or lower.

52. The method of claim 45, wherein the lubricant has a boiling temperature of around 100°C or higher.

53. The method of claim 45, wherein the lubricant has a surface tension of 20 dynes /cm or lower.

54.. The method of claim 45, wherein the lubricant has a viscosity in liquid phase of from 1 to 100 cP.

55. The method of claim 36, wherein the lubricant is mixed with a diluent that comprises: a perfluorinated hydrocarbon.

56. The method of claim 55, wherein the lubricant diluent is liquid at room temperature.

57. The method of claim 55, wherein the lubricant diluent does not decompose at a temperature of 200°C.

58. The method of claim 36, wherein the step of sealing the package further comprises:

covering the package with a package lid; and

hermetically bonding the lid to the package substrate.

59. The method of claim 36, wherein the step of disposing the capillary tubing into the package further comprising:

fixing the capillary tubing on the package such that the container can not move.

60. The method of claim 36, wherein the capillary tubing is placed in a cavity separated from a cavity in which the microelectromechanical device is placed, but connected to the cavity having the microelectromechanical device via a tunnel or a hole such that the lubricant evaporated from the container can pass through.

61. The method of claim 60, wherein the cavity having the container is in the package cover.

62. The method of claim 60, wherein the cavity having the container is in the package substrate.

63. The method of claim 36, wherein the capillary further comprises:

a coating film on the interior surface of the capillary tubing for improving the wettability to the lubricant.

64. The method of claim 36, wherein the capillary further comprises:

a coating film on the exterior surface of the capillary tubing for reducing the wettability to the lubricant.

65. The method of claim 36, wherein the capillary further comprises:

a coating film on the interior surface of the capillary tubing for improving the wettability to the lubricant; and

a coating film on the exterior surface of the capillary tubing for reducing the wettability to the lubricant.

66. The method of claim 36, further comprising:

heating the package.

67. A microelectromechanical package, comprising:

a package substrate;

a microelectromechanical device having a surface to be lubricated, wherein the microelectromechanical device is disposed on the package substrate;

a container containing a lubricant that evaporates from an opening of the container so and contacts the surface to be lubricated; and

a package cover that is bonded to the package substrate for sealing the package.

68. The package of claim 67, wherein the container is a capillary tubing.

69. The package of claim 67, wherein the container is a cylinder.

70. The package of claim 68, wherein the microelectromechanical device is a micromirror device.

71. The package of claim 70, wherein the micromirror device comprises a micromirror assembly having two substrates.

72. The package of claim 71, wherein the two substrates are bonded together; and wherein the bonded substrates have an opening between the substrates such that the lubricant flows through the opening and contact the surface to be lubricated between the substrates.

73. The package of claim 72, wherein the one of the two substrates is glass that is transmissive to visible light, and the other one is a standard semiconductor wafer.

74. The package of claim 73, wherein the glass substrate has an array of micromirrors formed thereon.

75. The package of claim 74, wherein said the other substrate has an array of electrodes formed thereon for deflecting the micromirrors.

76. The package of claim 75, wherein the glass substrate having the micromirrors is further to the package substrate than the substrate on which the electrode array is formed.

77. The method of claim 75, wherein the lubricant comprises a perfluoropolyether.

78. The method of claim 77, wherein the perfluoropolyether has a molecular weight of from 500 to 5000.

79. The method of claim 75, wherein the lubricant comprises a perfluorinated hydrocarbon.

80. The method of claim 79, wherein the perfluorinated hydrocarbon comprises 20 carbons or less.

81. The method of claim 80, wherein the perfluorinated hydrocarbon is selected from alkanes, alcohols, ethers and glycols.

82. The method of claim 75, wherein the lubricant comprises a perfluorinated hydrocarbon.

83. The method of claim 75, wherein the lubricant has a melting temperature of around 50°C or lower.

84. The method of claim 75, wherein the lubricant has a boiling temperature of around 100°C or higher.

85. The method of claim 75, wherein the lubricant has a surface tension of 20 dynes /cm or lower.

86. The method of claim 75, wherein the lubricant has a viscosity in liquid phase of from 2 to 100 cP.

87. The method of claim 75, wherein the lubricant is mixed with a diluent that comprises: a perfluorinated hydrocarbon.

88. The method of claim 87, wherein the lubricant diluent is liquid at room temperature.

89. The method of claim 87, wherein the lubricant diluent does not decompose at a temperature of 200°C.

90. The package of claim 75, further comprising: a sealing material between the package substrate and the package cover for hermetically sealing the package.

91. The package of claim 75, wherein the capillary tubing has an interior diameter of from 2 to 500 micrometers.

92. The package of claim 75, wherein the capillary tubing has an interior diameter of from 100 to 200 micrometers.

93. The package of claim 75, wherein the amount of the lubricant inside the capillary tubing is determined by an interior volume of the capillary tubing.

94. The package of claim 75, wherein the capillary tubing has an interior volume that generally equals a particular amount of lubricant necessary for lubricating the surface.

95. The package of claim 94, wherein the particular amount of the lubricant is from 10 pl to 10 μl.

96. The package of claim 95, wherein the particular amount of the lubricant is from 30 pl to 2 μl.